
उच्च दृश्यता के चेतावनी वस्त्र — विशिष्टि

(पहला पुनरीक्षण)

High Visibility Warning Clothes — Specification

(*First Revision*)

ICS 13.340.10

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भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDARDS

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Occupational Safety and Health Sectional Committee, had been approved by the Chemical Division Council.

High visibility warning cloth is one of the personnel protective equipment worn as a means to provide visual signal of the wearer's presence and intended to provide conspicuity of the wearer under any light conditions by day and under illumination by vehicle headlights in the dark. Conspicuity is enhanced by increasing the contrast between the clothing and its ambient background or surroundings.

This standard was first published in 2008. This standard was developed indigenously by taking considerable assistance from EN 471 : 1994 'High visibility warning clothing'.

In this revision, test method for testing performance when cleaning and finishing using tetrachloroethene is incorporated with considerable assistance taken from ISO 3175-2 : 2010 'Professional care, dry cleaning and wet cleaning of fabrics and garments — Part 2: Procedures for testing performance when cleaning and finishing using tetrachloroethene'.

The standard is applicable to all kinds of organizations irrespective of its complexity as well as hazards associated with it and is voluntary in nature like all other management systems. A system of this kind enables an organization to demonstrate its performance and conformity to the legal requirements. Certifying organization should provide information listing all the legislations as identified by the organization and covered in the certification process.

Two different colours for background and combined performance materials are defined, providing options for increasing wearer's conspicuity against most backgrounds found in urban and rural work environments. Users should consider the prevailing ambient background in which protection is required and select the colour providing the preferred contrast.

Higher photometric performance levels of retroreflective material provide greater contrast and visibility over wider viewing angles of safety clothing when seen in headlights during darkness. When greater conspicuity is required, the higher performance level of retroreflective material should be used.

Classes of visibility hazards are identified and appropriate markings for the clothing are suggested based on worker risk hazards, such as complex backgrounds, vehicular traffic density and speeds.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

HIGH VISIBILITY WARNING CLOTHES — SPECIFICATION (*First Revision*)

1 SCOPE

This standard specifies requirements and methods of tests for high visibility warning clothing as well as recommended configurations of the materials.

2 REFERENCES

The standards given below contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revisions, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
686 : 1985	Method for determination of colour fastness of textile material to daylight (<i>first revision</i>)
689 : 1988	Method for determination of colour fastness of textile materials to hot pressing (<i>first revision</i>)
762 : 1988	Method for determination of colour fastness of textile materials to hypochlorite bleaching (<i>first revision</i>)
766 : 1988	Method for determination of colour fastness of textile material to rubbing (<i>first revision</i>)
1966	Textiles — Bursting properties of fabrics — Determination of bursting strength and bursting distension :
(Part 1) : 2009	Hydraulic method
(Part 2) : 2009	Pneumatic method
1969 (Part 1) : 2009	Textiles — Tensile properties of fabrics — Determination of maximum force and elongation at maximum force : Part 1 Strip method
2454 : 1985	Method for determination of colour fastness of textile materials to artificial light (Xenon lamp) (<i>first revision</i>)
4802 : 1988	Method for determination of colour fastness of textile materials to dry-cleaning (<i>first revision</i>)

<i>IS No.</i>	<i>Title</i>
6489 (Part 1) : 2011	Textiles — Tear properties of fabrics : Part 1 Determination of tear force using ballistic pendulum method (Elmendorf)
7016 (Part 4) : 2003	Methods of test for coated and treated fabrics: Part 4 Rubber or plastics — Coated fabrics — Determination of resistance to damage by fabrics
12673 (Part 1) : 2014	Textiles — Determination of the abrasion resistance of fabrics by the martindale method : Martindale abrasion testing apparatus (<i>first revision</i>)
IS 15370 : 2005/ ISO 6330 : 2000	Textiles — Domestic washing and drying procedures for textile testing
IS/ISO 105-C06 : 1994	Textiles — Tests for colour fastness : Part C06 colour fastness to domestic and commercial laundering
IS/ISO 105 E01 : 2013	Method for determination of colour fastness of textile materials to water
IS/ISO 105 E04 : 2013	Method for determination of colour fastness of textile materials to perspiration

3 TERMINOLOGY

For the purpose of this standard the following terms and definitions shall apply.

3.1 Background Material — Coloured fluorescent material intended to be highly conspicuous in the daytime, but not intended to comply with the requirements of these guidelines for retroreflective material.

3.2 Certify — Testing by third party to verify performance requirements as specified in this standard

3.3 Coefficient of Luminous Intensity — Ratio of luminous intensity of the retroreflector in the direction of observation to the illuminance at the retroreflector on a plane perpendicular to the direction of the incident light.

3.4 Coefficient of Retroreflection (R_a) — The ratio of the coefficient of luminous intensity of a plane retroreflecting surface to its area and expressed in candela per lux per square metre ($\text{cd.lx}^{-1}.\text{m}^{-2}$)

3.5 Combined-Performance Material — Retroreflective material which is also a fluorescent material

3.6 Conspicuity — The characteristics of an object which determine the likelihood that it will come to the attention of an observer, especially in a complex environment which has objects competing for attention of the observer.

3.7 Entrance Angle — The angle between the illumination axis and the retroreflector axis.

3.8 Fluorescent Material — Material that emits optical radiation at wavelengths longer than it absorbed. These materials enhance daytime visibility, particularly during the hours of dawn and dusk.

3.9 High Visibility Warning Clothes — Personal protective safety clothing intended to provide conspicuity during both day time and night time usage.

3.10 Observation Angle — Angle between the illumination axis and the observation axis.

3.11 Photometric Performance Level — The effectiveness of retroreflective material in returning light to its source, expressed in Table 1 and Table 2 as combined material and measured in terms of Coefficient of Retroreflection (R_a).

3.12 Retroreflector Axis — Usually perpendicular to the surface of the retroreflective material.

3.13 Retroreflective Material — Material which is a retroreflector that is, it reflects the light falling on it, back to the source of light and is either not intended to comply with the requirements of these guidelines for background material, or is a combined-performance material.

3.14 Rotation Angle (ϵ) — Angle indicating the orientation of the specimen when it is rotated about the retroreflector axis.

4 CLASSIFICATION

4.1 Types

High visibility warning clothes are of two types depending on the colour for background and combined performance materials:

- a) *Type 1* – Fluorescent yellow – Green, and
- b) *Type 2* – Fluorescent orange – Red.

4.2 Each type of high visibility warning clothing are classified based on the level of conspicuity as follows:

- a) *Class 1* — For use in occupational activities that permit full and undivided attention to approaching traffic;
- b) *Class 2* — For use in occupational activities where users require greater visibility for inclement weather conditions, activities on or near roadways with higher traffic levels; and
- c) *Class 3* — For use in high-risk occupations when workers are exposed to high-speed traffic, or a wide range of weather conditions.

NOTE — The conspicuity classes and examples of applicable workers are provided in Annex A. While the area of materials used is driven by the type of garment and size of the wearer, Class 3 clothes intend to offer greater visibility against most urban and rural backgrounds than Class 2 clothes, which in turn are significantly superior than Class 1 clothes. Annex A provides a description of these conspicuity classes and the recommended applications.

5 REQUIREMENTS

5.1 Materials

5.1.1 Retroreflective and background materials shall conform to the performance requirements as specified in 5.3 and 5.4.

5.1.2 The material shall not dissolve or pucker when wiped with a soft cloth containing methylated spirit, kerosene, unleaded gasoline, methanol and naphtha solvent.

5.2 Garment Design

5.2.1 *Specific Design Requirements for Retroreflective Materials*

5.2.1.1 Width of bands

Bands of retroreflective material shall not be less than 50 mm for Class 3 and Class 2 clothes, and shall meet the minimum performance shown in Table 1 and Table 2. Class 1 clothes shall be constructed with retroreflective material bands of not less than 25 mm. Alternatively, Class 1 clothes can be constructed with combined-performance material meeting minimum performance requirements in Table 1 and Table 2 and shall not be less than 50 mm in width.

Table 1 Minimum Coefficient of Retroreflection ($\text{cd.lx}^{-1}.\text{m}^{-2}$) for Retroreflective Material
(Clauses 3.11, 5.2.1.1, 5.4.1 and C-3.2.1)

Sl No.	Observation Angle	Entrance Angle			
		5°	20°	30°	40°
(1)	(2)	(3)	(4)	(5)	(6)
i)	12'	330	290	180	65
ii)	20'	250	200	170	60
iii)	1°	25	15	12	10
iv)	1°30'	10	7	5	4

Table 2 Minimum Coefficient of Retroreflection (cd.lx⁻¹.m⁻²) for Combined-Performance Material (Clauses 3.11, 5.2.1.1, 5.4.1 and C-3.2.1)

Sl No.	Observation Angle	Entrance Angle			
		5°	20°	30°	40°
(1)	(2)	(3)	(4)	(5)	(6)
i)	12'	250	220	135	50
ii)	20'	120	100	75	30
iii)	1°	25	15	12	10
iv)	1°30'	10	7	5	4

5.2.1.2 Multiple bands

For multiple bands placed on the garment, the bands shall be placed at a spacing distance of at least equal to the width of the band.

5.2.1.3 Bands near bottom edge

For horizontal bands placed near the bottom edge of the jacket or vest, the spacing shall be not less than 50 mm above the bottom edge. For trousers, horizontal bands on the legs shall be not more than 350 mm above the bottom edge of the legs.

5.2.1.4 Bands on sleeves

Whenever horizontal bands are placed on full-length sleeves of coveralls and jackets, the band shall encircle the arm and be placed at the same height on the garment as the retroreflective band on the torso. Upper bands shall encircle the upper part of the sleeves between elbow and shoulder. Lower bands shall not be less than 50 mm from the bottom of the sleeve.

5.2.1.5 Gaps

Gaps in retroreflective and background material for the purpose of fastening devices shall not be more than 50 mm horizontally.

5.2.1.6 360° band placement

All classes of clothes shall have continuous areas of retroreflective material encircling the torso, placed in such a manner to provide 360° visibility of the wearer.

5.2.1.7 Minimum area of visible material and retroreflective material

Each class of high visibility safety clothes shall have the minimum area of materials incorporated in the garment in accordance with Table 3. The specified level of retroreflective material selected shall be indicated on the garment label as described in 6.1.1.

5.2.2 Garment Design Configurations

Coveralls, jackets and vests shall be designed to permit maximum visibility of the wearer. Bands of retroreflective material in the garments may be inclined

but to a maximum of $\pm 20^\circ$. Graphic examples have been given in Annex B.

NOTE — Maximum visibility may be obtained by endorsing:

- two horizontal bands of retroreflective material around the torso in case of coverall;
- with one or more horizontal bands of retroreflective material around the torso and bands of retroreflective material joining the uppermost torso band from the front to the back over each shoulder in case of jackets and vests; and
- two bands of retroreflective material should encircle the sleeves at the same height as those on the torso for coveralls and jackets with full-length sleeves.

Harnesses shall comprise a band of combined-performance retroreflective material encircling the waist and joining the waistband from the back to the front over both shoulders, the bands being not less than 50 mm wide.

NOTE — harnesses complying with this standard are not intended to provide protection against fall from heights.

Table 3 Minimum Areas of Visible Material (Clause 5.2.1.7)

Sl No.	Class of High Visibility Warning Clothing	Class 3	Class 2	Class 1
(1)	(2)	(3)	(4)	(5)
i)	Background material, m ²	0.80	0.50	0.14
ii)	a) Retroreflective material or combined performance material used in conjunction with background material, m ²	0.20	0.13	0.10
	b) Combined-performance material used without background material, m ²	—	—	0.20
iii)	Metre per retroreflective band width	3.9 m of 50 mm wide band	2.6 m of 50 mm wide band	a) 3.9 m of 25 mm wide band b) 1.97 m of 50 mm wide band

5.3 Colour

5.3.1 Colour of Background Material and Combined-Performance Retroreflective Material Prior to Exposure Tests

5.3.1.1 The chromaticity value of the background material and combined-performance retroreflective material shall lie within one of the areas given in Table 4 when measured at each of the two rotation angles in accordance with C-2.

5.3.1.2 The minimum luminance factor of the background material and combined-performance retroreflective material shall be as given in Table 4 when measured at each of the two rotation angles in accordance with C-2.

5.3.2 Colour Fastness of Background Material

5.3.2.1 Colour fastness to crocking

The colour fastness of background material to crocking both wet and dry shall be at least a grade 4.0 by the gray scale for staining when tested in accordance with IS 766.

Table 4 Colour Background Material and Combined Performance Material

(Clauses 5.3.1.1, 5.3.1.2, 5.3.2.4 and 5.3.3)

Sl No.	Colour	Chromaticity Coordinates		Minimum Luminance Factor β, Min
		X	Y	
(1)	(2)	(3)	(4)	(5)
i)	Fluorescent yellow-green	0.387	0.610	0.70
		0.356	0.494	
		0.398	0.452	
		0.460	0.540	
ii)	Fluorescent orange-red	0.610	0.390	0.40
		0.544	0.376	
		0.579	0.341	
		0.655	0.344	

5.3.2.2 Colour fastness to perspiration

The colour fastness of background material to perspiration shall be at least a grade 4.0 for colour change by the grey scale and at least a grade 3.0 for staining by the grey scale for staining when tested in accordance with IS/ISO 105 E04.

5.3.2.3 Colour fastness — When laundered, dry-cleaned, hypochlorite bleached and hot pressed

Colour fastness of background material shall be at least the grade specified in col 3 of Table 5 when determined in accordance with the test methods stated in col 4 of Table 5. Specimens shall be dried hanging in air at a temperature not exceeding 60°C with parts in contact only at the lines of stitching. Samples shall be pressed in the dry state only in case of hot-pressing.

5.3.2.4 Colour fastness of background materials after xenon test

The colour of background material after exposure shall be within the areas defined by the coordinates in Table 4 and the luminance factor shall be not less than the corresponding minimum values given in Table 4 when tested in accordance with IS 2454.

5.3.3 Colour Fastness of Combined-Performance Materials after Xenon Test

The colour of combined-performance materials after exposure shall be within the areas defined by the coordinates in Table 4 and the luminance factor shall be not less than the corresponding minimum values in Table 4. The light fastness of the combined-performance materials shall be determined in accordance with test method

specified in IS 2454. Exposure shall continue until the blue scale control standard number 5 has changed to step 3 of the grey scale for red and orange-red materials, and the blue scale control standard number 4 has changed to step 4 of the grey scale for yellow-green materials.

Table 5 Colour Fastness

(Clause 5.3.2.3)

Sl No.	Care Process	Fastness, Grade of the Grey Scale, At Least	Method of Test, Ref to
(1)	(2)	(3)	(4)
i)	Domestic and commercial laundry	Colour change: Grade 4 to 5; Staining : Grade 3.0	IS/ISO 105 C06
ii)	Dry-cleaning	Colour shade change : 4	IS 4802
iii)	Hypochlorite bleaching:	Colour shade change : 4	IS 762
	a) Domestic	a) Test conditions 5A	
	b) Commercial	b) Test conditions 4A	
iv)	Hot-pressing	Colour change : 4 to 5 Staining : 3.0	IS 689
v)	Water	Colour change and Staining : Grade 4	IS/ISO 105 E01

5.4 Photometric and Physical Performance Requirements for Retroreflective and Combined-Performance Materials

5.4.1 Performance Requirements of Retroreflective and Combined-Performance Material Prior to Test Exposure

When tested as per C-3, at the two rotation angles $\varepsilon_1 = 0^\circ$ and $\varepsilon_2 = 90^\circ$, retroreflective and combined-performance material shall comply with the minimum requirements for the coefficient of retroreflection stated in Table 1 and Table 2 respectively, at one of the two rotation angles; and shall be not less than 85 percent of the values stated in Table 1 and Table 2, respectively at the other rotation angle.

NOTE — The values for retroreflective material are for any colour.

5.4.2 Performance Requirements of Retroreflective and Combined-Performance Material after Test Exposure

The retroreflective and combined-performance material tested in accordance with 5.3 shall be exposed to the conditions as specified in Table 6. After exposure each test specimen shall fulfill the photometric requirements listed below:

- The coefficient of retroreflection (R_a), measured at observation angle 12° and entrance angle 5° , shall exceed $100 \text{ cd/(lx.m}^2\text{)}$ at one of the two orientations described in C-3; and
- It shall be not less than 85 percent of those required values at the other orientation.

Table 6 Test Exposure
(Clause 5.4.2)

Sl No.	Test Exposure	Procedure for Exposure of Retroreflective and Combined-Performance Retroreflective Material
(1)	(2)	(3)
i)	Abrasion	C-4.1
ii)	Flexing	C-4.2
iii)	Temperature variation	C-4.3
iv)	Washing	C-4.4
v)	Dry-cleaning	C-4.5
vi)	Influence of rainfall	C-4.6

When tested as per 4.3, the material shall show no physical damage likely to affect their utility as part of the garment, no appreciable change in colour, no migration of colour which would affect their visual performance as part of the garment, and shall retain the brightness level of at least $200 \text{ cd.lx}^{-1}.\text{m}^{-2}$ for retroreflective materials and $80 \text{ cd.lx}^{-1}.\text{m}^{-2}$ for combined-performance materials, when measured in accordance with C-3.

5.5 Mechanical Properties of Background Material

5.5.1 Tensile Testing

The tensile test in warp and weft direction shall fulfil the following requirement;

5.5.1.1 Tensile strength (in Newton 'N') divided by specific fabric mass (g/m^2) shall be ≥ 2 with minimum of at least 400 N.

5.5.1.2 Tensile strength shall be tested in accordance with IS 1969 (Part 1).

5.5.2 Tear Resistance for Coated Fabric and Laminates

The tensile testing shall not be applicable for Coated Fabric and Laminates. Tear Resistance shall be determined according to IS 6489 (Part 1) and have a minimum of 25 N.

5.5.3 Bursting Strength

The minimum bursting strength shall be 800 kN/m^2 , when measured in accordance with either IS 1966 (Part 1) or IS 1966 (Part 2) using sample specimen of 30 mm diameter.

6 PACKING AND MARKING

6.1 Marking

6.1.1 Each piece of warning clothing shall be marked

legibly on the product itself or on labels attached to the products, with the following information:

- Name, trade-mark or other means of identification of the manufacturer or authorised representative;
- Size designation;
- Fabric content; and
- Garment class and level of performance for the retroreflective material.

NOTE — The marking should be large enough to convey immediate understanding and to allow the use of readily legible characters.

6.1.2 BIS Certification Marking

The product may also be marked with the Standard Mark.

6.1.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6.2 Packing

The material shall be packed suitably as agreed to between the buyer and the seller.

7 INSTRUCTIONS FOR USE

Written information shall be supplied together with the garment on instructions for use, and shall include the following:

- Fitting — how to put on and take off, if relevant;
- Necessary warnings of misuse;
- Limitations on use;
- Storage — how to store and maintain correctly, with maximum periods between maintenance checks;
- Maintenance and cleaning — how to clean or decontaminate correctly, with complete washing and/or dry-cleaning instructions; and
- Number of cleaning processes without impairment of garment's performance level.

NOTE — Visibility of background and retroreflective materials will deteriorate with exposure and use.

8 SAMPLING AND CRITERIA FOR CONFORMITY

Sampling for test and the criteria for conformity shall be as per Annex C.

ANNEX A

(Clause 4.2)

CONSPICUITY CLASSES AND EXAMPLES OF APPLICABLE WORKERS

A-1 It is recommended that the selection of conspicuity class be based on the class definition that best represents the highest intermittent or continuous exposure encountered by the worker.

A-2 CONSPICUITY CLASSES

Conspicuity Class 1	Examples of Workers in Class 1
Conspicuity level for use in occupational activities which: - permit full and undivided attention to approaching traffic - provide ample separation of the worker from conflicting vehicle traffic - permit optimum conspicuity in backgrounds that are not complex, and - involve vehicle and moving equipment speeds not exceeding 40km/h	- workers directing vehicle operators to parking/service areas - workers retrieving shopping carts from parking areas - workers exposed to hazards of warehouse equipment traffic - roadside maintenance workers - delivery vehicle drivers
Conspicuity Class 2	Examples of Workers in Class 2
Conspicuity level for use in occupational activities where risk levels exceed those in Class 1, such as where: - greater visibility is desired during inclement weather conditions - complex backgrounds are present - workers are performing tasks which divert attention from approaching vehicle traffic - vehicle or moving equipment speeds exceed 40 km/h, and - work activities take place in or in near proximity to vehicle traffic	- roadway construction workers - utility workers - survey crews - railway workers at low risk areas - school crossing guards - high-volume parking personnel - toll gate personnel - airport baggage handlers and ground crew - emergency response personnel - law enforcement personnel - accident site investigators
Conspicuity Class 3	Examples of Workers in Class 3
Conspicuity level for use in occupational activities where risk levels exceed those in Class 2, such as where: - workers are exposed to traffic speeds exceeding 80 km/h - pedestrian worker and vehicle operator have high task loads, clearly placing the pedestrian worker in danger, and - the worker must be conspicuous through the full range of body motions at a minimum of 390m (1280 feet), and must be identifiable as a person	- roadway construction workers - utility workers - survey crews - emergency response personnel - railway workers at high risk areas (working on track such as gangman) - track machine staff, night patrol man, gate keeper etc)

A-2.1 Applicable Conditions

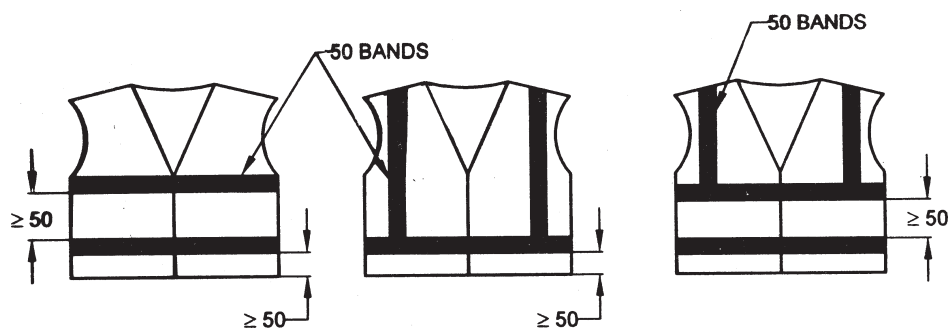
	<i>Class 1</i>	<i>Class 2</i>	<i>Class 3</i>
General description of conspicuity level	For use in occupational activities that permit full and undivided attention to approaching traffic	For use in occupational activities where users require greater visibility for inclement weather conditions, activities on or near roadways with higher traffic levels	For use in high-risk occupations when workers are exposed to high-speed traffic, or a wide range of weather conditions
Roadway conditions	Roadway or roadside conditions that provide ample separation of the pedestrian worker from conflicting vehicle traffic	Roadway situations which do not provide ample separation of the pedestrian from conflicting vehicle traffic	Roadway situations where the pedestrian and vehicle operator have high task loads- clearly placing the pedestrian in danger
Worker's background	Not complex — permitting optimum conspicuity	Complex-tasks which divert attention from approaching traffic	Complex
Vehicle and moving equipment speeds	Not exceeding 40 km/h	40 to 80 km/h	Exceeding 80 km/h
Examples of workers defined in this class	a) Workers who direct vehicle operators to parking/service locations b) Workers exposed to the hazards of warehouse equipment traffic c) Workers engaged in roadside/sidewalk maintenance d) Delivery vehicle drivers	a) Roadway workers in urban or high traffic suburban areas b) Utility workers c) Survey crews d) Railway workers e) School crossing guards f) High-volume parking and/or toll gate personnel g) Emergency response personnel h) Law enforcers (especially those directing traffic or conducting traffic accident site investigations)	a) Utility workers b) Survey crews c) Emergency response personnel d) Railway workers e) Accident site investigators

ANNEX B

(Clause 5.2.2)

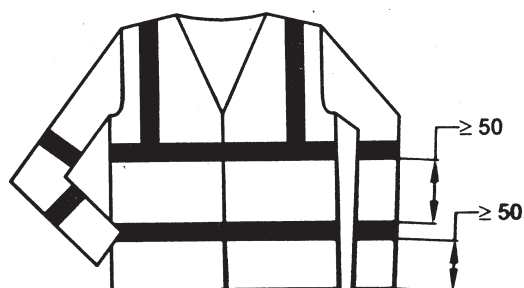
GRAPHIC EXAMPLES OF VESTS, JACKETS AND COVERALLS

B-1 Graphic examples of Vests (Class 2), Jackets (Class 3), Coverall (Class 3) and Coverall with inclined bands (Class 3) are given in Fig.1, Fig. 2, Fig. 3 and Fig. 4, respectively.



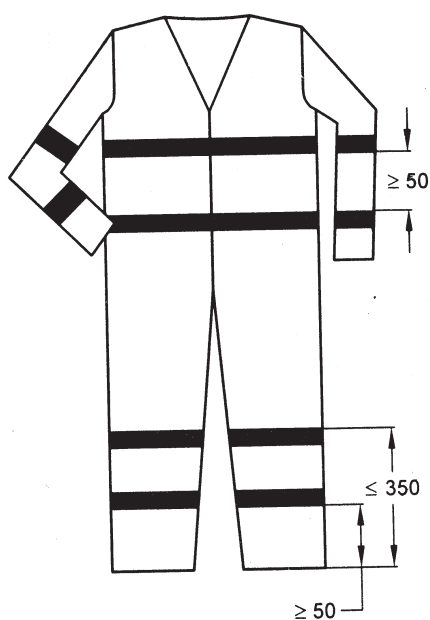
All dimensions in millimetres.

FIG. 1 EXAMPLE OF CLASS 2 VESTS



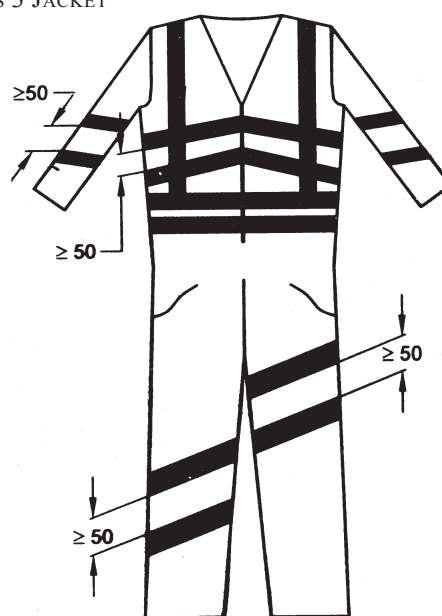
All dimensions in millimetres.

FIG. 2 EXAMPLE OF CLASS 3 JACKET



All dimensions in millimetres.

FIG. 3 EXAMPLE OF CLASS 3 COVERALL



All dimensions in millimetres.

FIG. 4 EXAMPLE OF CLASS 3 COVERALL WITH INCLINED BANDS RETROREFLECTIVE MATERIAL

ANNEX C

(Clauses 5.4, 5.5 and 8)

SAMPLING AND CRITERIA FOR CONFORMITY

C-1 SAMPLING AND CONDITIONING

C-1.1 Specimens

Test specimens shall be taken at random from commercially available quantities representative of commercially available quality.

C-1.2 Preparation of Specimens

The size, shape and quantity shall be as required for each test procedures.

C-1.3 Number of Tests

Unless otherwise specified, one specimen of each material shall be tested and shall comply with the minimum requirements.

C-1.4 Conditioning of Specimens

The specimens shall be conditioned for at least 24 h at $27 \pm 2^\circ\text{C}$ and 65 ± 5 percent relative humidity. If the tests are carried out in other conditions, the tests shall be conducted within 5 min after withdrawal from the conditioning atmosphere.

C-2 DETERMINATION OF COLOUR

C-2.1 General

Colour shall be measured in accordance with the procedure as given below with polychromatic illumination D_{65} and 45/0 (or 0/45) geometry and 2° standard observer.

C-2.1.1 Apparatus

C-2.1.1.1 Spectrometer, any suitable spectrometer designed for the measurement of reflectance factor using one or more of the standard influx and efflux geometries for colour evaluation.

C-2.1.1.2 Illuminator, polychromatic illumination D_{65} .

C-2.1.1.3 Dispersive Element, wavelength range from 300 to 830 nm and the wavelength measurement interval of 1 nm.

C-2.1.1.4 Detector, A photo electronic device (phototube or photomultiplier), silicon photodiode, or any other suitable photo detector.

C-2.2 Test Specimens

Test specimen shall be representative of the material being tested and should be uniform in optical properties

over the area illuminated and measured. The specimen shall have a black underlay with a reflectance of less than 0.04.

NOTE — Specimens should be handled carefully to avoid contamination. Care should be taken not to touch the area to be measured except for application of a suitable cleaning procedure.

C-2.3 Standardization

Standardize the spectrometer using an ideal (white) standard with an assigned reflectance factor 100.0 (percent) and use a highly polished black glass standard with an assigned reflectance factor of zero.

C-2.4 Procedure

C-2.4.1 To the extent allowed by the available instrument select the appropriate source type, illuminating and viewing geometry and the wavelength range and wavelength measurement interval.

C-2.4.2 When the instrument is interfaced to a computer so that calculation of CIE tristimulus values and derived color coordinates automatically follows measurement, select the variables defining these computations.

C-2.4.3 Measure the color coordinates based on the instrument manufacturers instructions.

C-3 METHOD FOR DETERMINATION OF RETROREFLECTIVE PHOTOMETRIC PERFORMANCE

C-3.1 General

The coefficient of retroreflection (R_a) shall be determined in accordance with the procedure as specified below in C-3.2.

Measurements shall be made on square samples of 10 cm × 10 cm or of the size of the pre tested samples.

R_a for the sample shall be measured at the specified observation angle and entrance angle for both the 0° , and 90° positions of the rotation angle (ϵ). The position 0° is determined by one of the following means:

- A clear datum mark on each sample; and
- A clear instruction given by the manufacturer of the material.

If no mark or instruction exists, the position $\epsilon = 0^\circ$ can be chosen at random.

C-3.2 Apparatus

C-3.2.1 Suitable retroreflectometer designed for the

measurement of coefficient of retroreflection (R_a) of sheets and tapes used for High visible warning clothes as per requirements as specified in Table 1 and Table 2.

C-3.2.2 The portable retroreflectometer should be calibrated with standards as per equipment manufacturers' instructions before the measurement.

C-4 RETROREFLECTION AFTER TEST EXPOSURE

C-4.1 Abrasion

The test sample shall be abraded in accordance with IS 12673 (Part 1), using a woollen fabric abradent for 5 000 cycles, using a weight of 9 kPa.

C-4.2 Flexing

The test sample shall be flexed in accordance with IS 7016 (Part 4) for 7 500 cycles.

C-4.3 Exposure to Temperature Variation

Specimens of the size of 180 mm × 30 mm shall be exposed continuously to a cycle of changing temperatures,

- a) for 12 h at $50 \pm 2^\circ\text{C}$ immediately followed by
- b) for 20 h at $-30 \pm 2^\circ\text{C}$; and
- c) for conditioning for at least 2 h in accordance with C-1.

C-4.4 Washing

C-4.4.1 When the marking on the garment (*see* 6.1.1) indicates that it is suitable for washing, the retroreflective material shall be washed for a minimum of 50 washing cycles as per the procedure defined in C-4.4.2.

C-4.4.2 Three clothing fabric specimens 300 mm × 250 mm shall be prepared with two stripes of retroreflective material, each 250 mm × 30 mm, with a distance between two stripes of 30 mm. The test samples shall be washed for a minimum of 50 cycles in accordance with IS 15370 using Type A washing machine and procedure 2A for separate performance retroreflective material, procedure 5A for combined performance material.

C-4.5 Dry Cleaning

When the marking on the garment indicates that it is suitable for dry-cleaning, the material shall be processed for a minimum of five dry cleaning cycles in accordance with method C-4.5.1.

C-4.5.1 Procedure

C-4.5.1.1 The mass of the complete load, measured to ± 0.1 , shall be calculated from the cage volume, for

normal materials in the proportion of $50 \pm 2 \text{ kg/m}^3$ and for sensitive and very sensitive materials in the proportion of $33 \pm 2 \text{ kg/m}^3$. Unless the mass of a single specimen (fabric, composite garment) exceeds 10 percent of the mass of the load, the mass of the test specimen(s) shall not exceed 10 percent of the mass of the load. The remainder of the load shall consist of ballast.

C-4.5.1.2 Place the conditioned load in the machine and charge the machine with distilled tetrachloroethene, containing 1g/litre of sorbitan mono-oleate so that the liquor ratio, calculated from the volume of the solvent in drum, is $5.5 \pm 0.5 \text{ l/kg}$ of the load. Maintain the solvent at $(30 \pm 3)^\circ\text{C}$ throughout the cleaning operation.

C-4.5.1.3 Prepare a fresh emulsion by mixing, per kilogram of load, 10 ml of sorbitan mono-oleate with 30 ml of tetrachloroethene and then whilst stirring adding 20 ml of water. This corresponds to 2 percent of water calculated on the mass of the load.

If the mixing of the detergent with tetrachloroethene outside the machine is not permitted, a mixture of the detergent and water may be added directly into the machine. Precautions shall be taken to avoid uneven distribution of the individual components in the load. Any deviation from the procedure shall be noted in the test report.

Start the machine with the filter circuit shut off, and 2 min after the cage inlet has closed, add the emulsion slowly over a period of $30 \pm 5 \text{ s}$ to the machine between the cage and the drum below the level of the solvent.

C-4.5.1.4 Switch the machine on and allow it to run for 15 min. Do not use the filter circuit for the duration of the test.

C-4.5.1.5 Drain the solvent and centrifugally extract the solvent from the load for 2 min (including at least 1 min at full extraction speed).

C-4.5.1.6 Introduce pure dry solvent at the same liquor ratio as that given in C-4.5.1.2 and rinse for 5 min. Drain and extract again for 3 min (including at least 2 min at full extraction speed).

C-4.5.1.7 Dry the load in the machine air for an appropriate time, preferably using an automatic solvent dryness control. After drying, blow air, at ambient temperature, through the rotating load for at least 5 min.

C 4.5.1.8 Immediately remove the test piece from the machine. Place garments individually on hangers and place fabric specimens on a flat surface for at least 30 min before finishing.

C 4.5.1.9 Carry out finishing treatments appropriate to the test specimen from the following methods and record the processing condition used.

- a) *Method A* : No finishing
- b) *Method B* : Finishing with an iron
- c) *Method C* : Finishing with a steam press
- d) *Method D* : Steaming on a press or table
- e) *Method E* : Steaming on a mannequin or in a cabinet
- f) *Method F* : No suitable finishing method could be found. Report methods and conditions attempted and reasons for unsuitability.

Record actual steaming times to allow for the reaction times of steam pedal switches and timer mechanisms. The purpose of finishing after dry-cleaning is to restore an article to its original condition before use. The amount and type of finishing should be consistent with the fabric/garment properties and the restorative requirements.

NOTE — Steaming/Vacuuming times for Method C and Method D vary, for example from 2 ± 1 s actual steam 5 ± 1 s vacuum for a light weight garment to (4 ± 1) s / (8 ± 1) s for heavy garments. Steaming in Method C consist of top steam, only to equate to good pressing practice. It is likely that Method E is used with Method B or Method C to achieve a good standard of finish.

C-4.6 Retroreflective Performance in Rainfall

Samples shall be tested in accordance with the method specified under C-4.6.1 to C-4.6.3.

C-4.6.1 Principle

A specimen of the material is mounted in a vertical plane and subjected to a continuous spray of water droplets. Measurements are made of the coefficient of retroreflection of the wetted surface while the spray is maintained, simulating the optical behavior of a surface in a shower of rain.

C-4.6.2 Apparatus

A suitable apparatus for mounting the specimen in the spray of water is illustrated in Fig. 5.

The specimen *A* is supported on the vertical specimen holder *B* above the catch trough *C* and drain *D*. The specimen holder is rigidly attached to the goniometer table (not shown) but is held away from it. The spray nozzle *E* is rigidly supported in a position which is fixed relative to the specimen and is supplied with tap water at constant but adjustable pressure through a flexible joint *F* or hose.

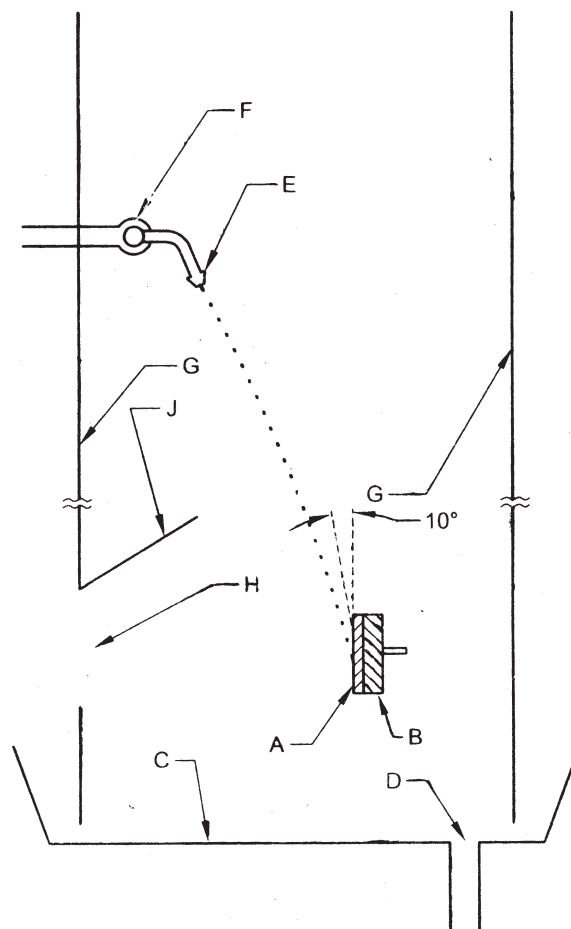


FIG. 5 APPARATUS FOR THE WET RETROREFLECTIONS TEST

The nozzle is 1 m away from the specimen and is so angled that the spray strikes the specimen at an angle of 10° to the vertical. The specimen, specimen holder and spray nozzle are enclosed in a cover G designed to protect the optical apparatus from water.

Preferably, the cover is made of or incorporated large areas of rigid transparent plastics material for visibility and has at least one removable panel or door for access. A square aperture H of side 150 mm is provided for the light path and a gutter J protects this aperture from falling water. The region of the cover near to this aperture is painted matt black to reduce spray reflections. The nozzle consists of an orifice of diameter 1.19 mm with an appropriately designed feed pipe producing a substantially uniform solid cone spray.

C-4.6.3 Procedure

Calibrate the apparatus for measuring the coefficient of retroreflection R_a with the wet testing apparatus in

place, under both dry and wet conditions and determine a correction for change in spray light between these two conditions.

Mount a flat, square specimen of the material of side not less than 50 mm in a vertical plane of the vertical specimen holder so that the holder does not protrude beyond the edge of the specimen at any point. If the material is orientation sensitive when dry, as described in 6.1 mount it so that measurements can be made at the orientation which gave the lowest performance when dry. Adjust the nozzle and water supply to subject the specimen to a spray of ordinary tap water such that the whole face of the specimen is within the envelope of the spray, the angle 8 between the surface of the specimen and the water striking it is not less than 5° , and the flow rate striking the specimen is equivalent to a rainfall, in millimeters per hour, of $50/\tan 8$ as measured in a horizontal collector. Maintain the spray in a steady state for at least 2 min before and throughout the measurement.

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